

Supplementary Materials File S3

Table S2. Cluster Dependency Labels in the 2000s.

Cluster-ID	Tags	Top Terms (Latent Semantic Analysis)	Top Terms (Log-Likelihood Ratio)	Top Terms (Mutual Information)
#0	sustainable development	sustainable development; regional planning; urban governance; urban sustainability; new urbanism urban planning; urban sustainability; urban intensification; sustainability policy; urban waterfronts	sustainable development (17.16); gentrification (16.42); urban political ecology (16.42); Vancouver (10.93); building assessment system (10.93)	subjectivity; urban intensification; environmentalism; planning practice; Canada
#1	landscape preferences	urban ecology; landscape preferences; human well-being; habitat fragmentation; landscape indices green space; restorative environments; noise annoyance; road traffic; urban sustainability	landscape preferences (9.25); restorative environments (9.25); sustainable cities (9.25); green space (7.22); urbanization (6.54)	rainwater harvesting; food production; landscape professionals; invasiveness; urban soil quality
#2	physical activity	physical activity; compact development; urban ecology; infrastructure planning; city planning land use planning; environmental justice; basic amenities; extraterritorial jurisdiction; compact development	physical activity (28.26); built environment (21.13); policy (10.29); environmental justice (10.29); public health (7.49)	land use united states; town and city planning; mass transit; features; infrastructure
#3	ecology scenarios	landscape ecology; ecosystem services; urban greenspace; urban greening; ecological planning harmonious degree; developmental degree; complex urban ecosystem; recycling degree; dispersal patchmapper	scenarios (9.71); harmonious degree (9.71); public lands (9.71); developmental degree (9.71); urbanization (5.81)	Barcelona; biodiversity indicators; balance of carbon-oxygen; land suitability indices; systemic approach
#4	landscape metrics	urban ecology; landscape ecology; land-use patterns; ecosystem function; green space landscape metrics; urban green spaces; moving window; gradient analysis; urban-rural gradients	landscape metrics (5.72); urban spatial dynamics (4.83); interdisciplinary (4.83); ecosystem function (4.83); hydrology (4.83)	urban spatial dynamics; interdisciplinary; ecosystem function; hydrology; watershed
#5	biotic homogenization	urban ecology; urban planning; passer domesticus; Sturnus vulgaris; bird species richness conservation planning; urban landscape; environmental legislation; edge effect; urban vegetation	biotic homogenization (8.32); isolation (8.32); urban flora (8.32); conservation planning (4.98); urban landscape (4.77)	habitat; passer domesticus; species extinction; habitat disturbance; rapid assessment
#6	birds	indicator species; surrogate taxa; ecosystem management; life history; umbrella species landscape pattern indices; land use change; habitat fragmentation; santa monica mountains; coastal sage scrub	birds (19.23); landscape (12.8); riparian forest (9.74); conservation (8.07); urban ecology (7.08)	matrix; red-listed forest birds; great basin; threshold response; thresholds
#7	tree management	urban forest; institutional forest; species diversity; park forest; roadside forest tree management; livable city; greenspace planning; urban greenery; urban forestry	tree management (16.24); urban tree (12.45); urban greening (10.76); urban forest (9.61); Guangzhou (8.74)	urban trees; amenity vegetation; livable city; development history; urban soil
#8	ecology vulnerability	land-use change; information-driven economy; land-use pattern; industrial economy; primary productivity conservation planning; biological invasions; spatial modeling; future land use changes; ecological mechanisms	vulnerability (12.83); simulation modeling (6.4); reserve selection (6.4); information-driven economy (6.4); future land use changes (6.4)	simulation modeling; reserve selection; information-driven economy; future land use changes; spatial modeling
#9	landscape fragmentation	sustainable development; time series; environmental indicators; effective mesh size; landscape fragmentation urban sprawl;	California (9.92); time series (9.92); wildland-urban interface (8.53); agriculture (6.28); conservation subdivision (6.28)	landscape fragmentation; detection probabilities; spatial statistic; Mayacmas Mountains; traffic

#10	urbanization gradient	Russian river; ecological thresholds; exurban development; salmonid spawning habitat urban ecology; metro manila; urban planning; urban landscape; environmental gradient urban planning; bird richness; policy recommendations; habitat attributes; urbanization gradient	change detection (12.11); Lake Tahoe (8.39); remote sensing (6.76); urban ecology (6.5); urbanization gradient (6.04)	urbanization gradient; community composition; exotic plant species; landcover; montane forest structure
#11	natural perception	urban green space; ecosystem service; visitor perception; naturalistic landscape design; outdoor recreation compact city; amenity value; housing market; environmental benefits; urban natural area	perception (11.36); china (10.05); Guangzhou (9.11); quality of life (7.66); understanding (5.67)	understanding; park design; outdoor recreation; green network; urban natural area
#12	urban ecology	urban ecology; garden boundaries; stable isotopes; green infrastructure; tree species richness benthic index; landscape pattern; of biotic integrity; impervious surface; aquatic macroinvertebrates	urban ecology (8.16); scaling (5.43); Australia (5.43); complex systems modeling (5.34); socioecosystem (5.34)	complex systems modeling; socioecosystem; functional groups; benthic index of biotic integrity; institutions
#13	restoration	urban ecology; ecosystem services; land remediation; soil formation; biotic integrity soil quality; urban regeneration; land remediation; soil ecology; urban design	restoration (7.17); biotic integrity (6.83); soil formation (6.83); biotic indices (6.83); soil ecology (6.83)	biotic integrity; soil formation; biotic indices; soil ecology; green roof
#14	equity	environmental design; environmental psychology; public spaces; urban climate; climate planning infrastructure systems; sustainable neighborhood design; urban forestry; city planning; public service engineering	equity (14.72); health (14.72); environment (9.28); energy (7.33); climate planning (7.33)	energy; climate planning; buildings; transport; environmental psychology
#15	regulationist approach	reserve design; ecosystem processes; gis analysis; habitat conservation plans; urban interface local knowledge; environmental health; community planning; urban interface; regulationist approach	regulationist approach (9.58); governance (9.58); rescaling (9.58); urban regime theory (9.58); wildland/urban interface (9.58)	regulationist approach; governance; rescaling; urban regime theory; wildland/urban interface
#16	forest	forest; habitats; urban; greenbelt; urban ecology environmental design; sustainable development; conservation subdivision; forest; habitats	forest (6.28); environmental policy (6.28); open spaces (6.28); Israel (6.28); river corridors (6.28)	urbanization gradient; habitat; biotic integrity; passer domesticus; urban spatial dynamics
#17	urban environmental transition	globalization; functional city system; Asia-pacific; urban sustainability; urban environmental transition	urban environmental transition (11.63); globalization (11.63); Asia-pacific (11.63); functional city system (11.63); urban sustainability (6.65)	urban ecology; urbanization; biodiversity; urban environmental transition; globalization
#19	residential mobility	compact city policy; sustainable development; compact cities; residential preferences; residential mobility residential mobility; sustainable development; compact cities; compact city policy; residential preferences	residential mobility (20.96); compact city policy (20.96); compact cities (10.36); neighborhood (10.36); residential preferences (10.36)	residential mobility; compact city policy; compact cities; neighborhood; residential preferences
#21	ground survey	land cover; landscape; spatial scale; ground survey; remote sensing	ground survey (11.63); spatial scale (8.87); remote sensing (7.15); land cover (5.92); landscape (5.4)	urban ecology; urbanization; biodiversity; ground survey; spatial scale

The terms highlighted in bold indicate the labels for clusters derived from the initial annotations.

Table S3. Cluster Dependency Labels in the 2010s.

Cluster-ID	Tags	Top Terms (Latent Semantic Analysis)	Top Terms (Log-Likelihood Ratio)	Top Terms (Mutual Information)
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#0	health	green space; urban sustainability; regression analysis; psychological restoration; exposure assessment urban planning; mental health; natural space; methodology refinement; exposure assessment	mental health (61.49); physical activity (55.81); green space (54.37); health (36.67); greenness (30.68)	blue health; ageing; allergy hazard; community values; attitudes
#1	urban ecology	urban ecology; urban environmental management; urban nature conservation; habitat connectivity; nitrogen management ecosystem services; urban planning; biodiversity conservation; urban ecosystems; urban green space	urban ecology (54.99); stream restoration (23.92); urbanization (21.85); novel ecosystems (19.02); indicator species (17.93)	community composition; Acer negundo; greenhouses; home gardens; human-wildlife interactions
#2	ecosystem services	ecosystem services; spatial planning; Delphi survey; strategic environmental assessment; environmental impact assessment green infrastructure; social-ecological systems; health risk assessment; urban sustainability; planning strategies	ecosystem services (13.88); built environment (13.29); walking (12.95); health promotion (11.05); Landsat (11.05)	civic networks; conversion of land use and its effects (clue-s) model; built infrastructure; change analysis; city logistics
#3	urban heat island	urban heat island; urban green infrastructure; cool island; human comfort; urban heat mitigation land surface temperature; landscape pattern; landscape metrics; Tianjin-Hebei urban agglomeration; interpretative ability	urban heat island (198.06); environment (89.84); thermal comfort (70.1); land surface temperature (68.95); microclimate (63.43)	environmental simulation; cooling intensity; blue-green cities; assessment approach; heat mitigation strategies
#4	ecosystem services	ecosystem services; systemic solutions; rapid assessment; urban forestry; socio-environmental equity green infrastructure; central Europe; cross-city approach; sustainable urban drainage systems; cost-benefit analysis	ecosystem services (61.43); urban ecosystem services (38.12); mapping (23.83); green infrastructure (22.52); urban planning (19.68)	earthworms; cantons; Colombo; agricultural land-use; Apulia
#5	green infrastructure	green infrastructure; urban greening practices; multi-disciplinary collaboration; urban green development; European biodiversity strategy ecosystem services; urban ecology; landscape planning; multi-scale approach; participatory mapping	green infrastructure (68.75); sponge city (26.34); stormwater management (24.93); green stormwater infrastructure (24.88); urban resilience (24.55)	adaptation pathway; engineering infrastructure; environmental accounting; community greening; communities
#6	smart city	urban sustainability; environmental indicators; bibliometric analysis; tianjin eco-city kpi; geographical analysis smart cities; smart governance; urban quality assessment; urban industrial symbiosis; circular economy	smart city (149.19); smart cities (71.56); eco-city (67.78); ecosystem services (46.49); smart sustainable cities (44.51)	computation architecture; cybernetics; context-aware computing; degrowth; climate change adaptation policies
#7	climate change	climate change; sustainable development; carbon economy; strategic planning; strategic thinking urban metabolism; urban ecology; ecological network analysis; ecological hierarchy; greenhouse gases	climate change (33.91); ecosystem services (25.64); green infrastructure (19.09); London (18.63); transport (18.63)	cooperative; socio-technical transition theory; Rome; eco-economy; environmental risks
#8	urbanization	ecosystem services; land use simulation; logistic-ca model; Wuhan urban agglomeration; human ecological demand urban expansion; scenario analysis; shared socioeconomic pathways; chang bai mountain; cellular automata model	urbanization (51.34); China (51.05); urban expansion (33.79); urban growth (30.84); green infrastructure (28.11)	geographically and temporally weighted regression; CA-Markov model; dmsp/ols; centrality; land system design
#9	green roof	green roofs; surface energy balance; plant communities; experimental measurements; human exercise physiology urban heat island; urban planning; green infrastructure; stormwater management; plant communities	green roof (53.88); green roofs (47.9); plant traits (26.61); green facades (19.95); vegetated roofs (19.95)	climate-sensitive urban design; sustainable built environment; mixed-sewage-sludge substrate (msss); succession; flora

#10	air quality	green infrastructure; air pollution; leaf characteristics; traffic-based pollution; Miani Sahib ecosystem services; urban green spaces; street trees; soil carbon content; pervious-imperious surfaces	air quality (48.25); particulate matter (31.76); air pollution (30.86); trees (23.45); urban air quality (23.45)	economic stratification; lagrangian stochastic model; cfd; deposition velocity; foliage density
#11	public perception	ecosystem services; nature-based solutions; urban flooding; public perception; greenhouse gases green infrastructure; cross-city approach; central Europe; questionnaire survey; human health	public perception (18.47); urban atlas (17.51); provisioning ecosystem services (17.51); survey (13.13); biocultural diversity (12.77)	Karachi; beliefs; endangered plant species; multi-criteria evaluation; e-governance
#12	urban biodiversity	urban ecology; green infrastructure; conservation planning; urban parks; plant richness urban planning; ecosystem services; green space; urban vegetation; climate adaptation	urban biodiversity (49.13); biodiversity (32.27); conservation (27.61); species richness (27.4); pollinators (26.83)	accessibility of green spaces; cdv; ecosystem function; edge contrast; chloride)
#13	environmental justice	environmental justice; social-ecological systems; urban ecosystems; residential segregation; American free trade agreement ecosystem services; cluster analysis; environmental inequality; social justice; spatial distribution	environmental justice (68.62); environmental gentrification (38.46); urbanization (18.92); vacant land (16.46); spatial accessibility (16.46)	community bonding; accessibility indicator; business case; design practice; 2sfca improve model
#14	residential landscape	ecosystem services; urban planning; urban development; small actions; print media green infrastructure; climate change; urban design; urban forest; residential landscapes	residential landscape (12.09); urban area (12.09); residential landscapes (12.09); residential encroachment (12.09); urban densification (12.09)	garden complex; modis enhanced vegetation index (evi); private urban forest; citizens benefits; private green spaces
#15	urban metabolism	urban metabolism; urban planning; energy consumption; water supply; water scarcity industrial ecology; climate change; business models; technological transition; resource management	urban metabolism (157.67); industrial ecology (66.42); ecological network analysis (32.46); green infrastructure (24.58); ecosystem services (23.69)	jing-jin-ji urban agglomeration; flexible devices; breeam communities; social ecology; megacity
#16	land-use planning	ecosystem services; urban biodiversity; ecological scales; adaptive governance; public perception urban ecology; urban forest; health perception; environmental psychologists; nature perception	land-use planning (8.86); ecological planning (7.99); woodland birds (7.72); green system (7.72); urban open spaces (7.72)	woodland birds; green system; urban open spaces; dense city; open space index
#17	urban regeneration	climate change; adaptive capacity; land use change; green infrastructure; urban climate resilience urban regeneration; design methods; political mindfulness; inner transition; organizational mindfulness	urban regeneration (27.35); South Africa (15.79); local government (9.18); ecosystem services (8.22); inclusive governance (7.89)	inclusive governance; result; urban geoengineering; structures and design; mdantsane township

The terms highlighted in bold indicate the labels for clusters derived from the initial annotations.

Table S4. Cluster Dependency Labels in the 2020–2023.

Cluster-ID	Tags	Top Terms (Latent Semantic Analysis)	Top Terms (Log-Likelihood Ratio)	Top Terms (Mutual Information)
#0	health	green space; ecosystem services; nature-based solutions; systematic review; ecosystem disservices mental health; socio-environmental justice; green justice; fine-scale green space analysis; campus environment	mental health (119.51); green space (110.77); physical activity (50.83); health (46.82); public health (44.4)	16 s ribosomal rna; 0; birch pollen allergy; blue health; birth cohort
#1	urban heat island	urban heat island; mitigation strategies; building energy consumption; research method; climatic comfort land surface temperature; landscape metrics; cool island	urban heat island (274.9); land surface temperature (265.11); cooling effect (73.51); surface urban cooling intensity; heat island (55.1); urban heat islands (44.06)	climatic comfort; building climate zone; urban cooling intensity; cemeteries; composition and configuration

		effects; cooling gradient; urban green space planning		
#2	sponge city	green infrastructure; climate justice; climate gentrification; adaptation planning; urban green areas ecosystem services; urban planning; environmental justice; urban sustainability; sensitivity analysis	sponge city (151.38); green infrastructure (149.92); stormwater management (89.78); low impact development (72.53); stormwater (36.22)	adaptation pathway; above-ground biomass; bibliometric method; boundary object; bird abundance
#3	ecosystem services	ecosystem services; urban planning; green infrastructure; urban ecosystem services; systematic literature review ecosystem service value; weighted regression; nansihu lake basin; urban sustainability; regression analysis	ecosystem services (116.36); urbanization (78.97); ecosystem service value (69.43); ecosystem services value (47.42); driving factors (30.85)	cvm; coastal zones; blue carbon; central Yunnan city cluster; coldspots
#4	accessibility	environmental justice; nature connection; urban growth machine; spatial differentiation; legal status urban green space; green space justice; urban green space distribution; socioeconomic inequalities; human geography	accessibility (97.86); environmental justice (78.98); urban green space (46.64); inequity (31.72); gini coefficient (30.09)	china social survey; accessibility analysis; 4?a? framework; built environments; children's geographies
#5	urban expansion	urban expansion; sample optimization; annual land cover mapping; spatio-temporal consistency modification; remote sensing data ecosystem services; land use change; ecological protection redlines; urban vitality; watershed	plus model (132.61); urban expansion (115.32); invest model (112.68); habitat quality (109.82); carbon storage (108.45)	1; dem digital elevation model; chengdu-chongqing urban agglomeration (ccua); built land; dynamic land-use simulation
#6	nature-based solutions	nature-based solutions; ecosystem services; green space; ecosystem disservices; systematic review green infrastructure; climate change; natural risks; growing roofs; urban sustainability	nature-based solutions (265.5); climate change adaptation (31.08); nature-based solutions (nbs) (27.66); nbs (25.84); urban governance (25.45)	appropriation of nature; (eco)poverty; benefit transfer; agri-food supply chain; Atlantic rainforest
#7	COVID-19	urban planning; air quality; socioeconomic factors; urban density; text analysis ecosystem services; spatial assessment; green space quality; nature-based interventions; planetary health	COVID-19 (254.92); recreation (45.39); lockdown (33.55); pandemic (28.05); COVID-19 pandemic (27.95)	ces; Ankara; COVID-19 mortality; correspondence analysis; capital
#8	outdoor thermal comfort	urban heat island; mitigation strategies; building energy consumption; research method; landscape metrics outdoor thermal comfort; physiological equivalent temperature; urban green spaces; heat stress; physical activity	outdoor thermal comfort (123.5); thermal comfort (116.72); envi-met (109.88); microclimate (96.08); urban heat island (77.86)	cooling impact; ecosystem function; foliage density; avenue trees; decision trees
#9	coupling coordination degree	urban agglomeration; ecological environment; Yangtze river delta; economic development; gray correlation coupling coordination degree; water environment; temporal variation; vector autoregression; Wuhan urban agglomeration	coupling coordination degree (112.86); ecosystem health (78.34); ecological environment (72.9); urbanization (58.88); new-type urbanization (49.03)	ccd; co2 emission; cloud computing; ccdc; geographical detector model
#10	ecological security pattern	ecological security pattern; ecological corridors; ecological source; landslide sensitivity assessment model; circuit theory model circuit theory; ecological security; land use simulation; Taihu lake basin; ecological source	ecological security pattern (169.37); circuit theory (95.13); ecological network (89.66); ecological corridor (76.67); ecological source (57.95)	ecological groups; pinch points; main agricultural production areas; landscape pattern evolution; important ecological regions
#11	urban resilience	urban resilience; ecosystem services; climate change adaptation; informal settlements; pacific sids sustainable development; climate change; urban planning; compact city; urban density	urban resilience (170.87); resilience (47.82); urban sustainability (20.67); Shenyang city (19.5); sustainability (19)	community governance; exposure-connectedness-potential (ecp); fuzzy set qca; critical obstacle; conflicting goals

#12	urban biodiversity	ecosystem services; nature-based solutions; green space; ecosystem disservices; urban vegetation green infrastructure; urban planning; urban ecosystem services; systematic literature review; insect conservation	urban biodiversity (151.84); biodiversity (96.75); urban ecology (53.44); landscape ecology (28.61); functional diversity (27.04)	biodiversity and design; biodiversity threats; bathymetry; advance regeneration; anthropogenic habitat
#13	production–living–ecological space	sustainable development; green innovation; green development; eco-industrial park; quasi-natural experiment living-ecological space; land use function; spatial optimization; land use modeling; text analysis	production–living–ecological space (48.2); production–living–ecological spaces (38.4); green total factor productivity (37.66); land use function (34.12); rural revitalization (34.12)	a; e-commerce pilot city policy; comprehensive innovation reform; island carrying capacity; fang county
#14	environmental justice	environmental justice; urban planning; green space; European green capital; multiscalar governance green infrastructure; climate justice; adaptation planning; climate gentrification; territorial development	environmental justice (120.86); gentrification (96.5); green gentrification (80.53); climate justice (42.71); urban greening (29.23)	green -blue infrastructure; >; green public space quality; fantasy; environmental racism
#15	particulate matter	green infrastructure; urban greening; urban ecosystem services; urban forest management; environmental equity air pollution; large-eddy simulation; permeable surfaces; biogenic volatile organic compound; indoor air quality	particulate matter (94.1); air pollution (92.42); air quality (67.01); urban air quality (50.1); urban trees (32.31)	5; computational fluid dynamics (cf) model; community mobilization and stakeholder engagement; gaseous pollutants; effectiveness
#16	green roofs	green roofs; green infrastructure; public policies; policy incentives; limiting factors urban heat island; building energy consumption; research method; mitigation strategies; leaf stomatal resistance	green roofs (131.24); green roof (97.51); green walls (47.1); Mediterranean climate (26.43); vertical greening systems (26.43)	do-it-yourself; l; building-integrated vegetation; global review; community awareness
#17	smart city	digital economy; coupling coordination; land conflict; land ecology; urban living labs smart cities; resilient cities; urban areas; smart resilient cities; indicators bank	digital economy (124.72); smart city (108.54); spatial spillover effect (42.93); smart cities (36.89); ecosystem services (27.43)	knowledge-based development; ridesharing; national big data comprehensive pilot zone; green and high-quality development; digital twins

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